THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.*

BY SIDNEY I. SMITH.

It is one of the ever-wise provisions of nature, that every land has a vegetation and an association of animals peculiar to itself, that every sea and every zone of ocean is peopled with life found nowhere else. There is such a wealth of conception in the forms of organic life, that there is no need of their repetition in distant lands. The palms and the reef corals never wander from the tropics; the humming-birds are as peculiarly American, as the Mississippi or the Andes. It is specially the province of modern science to explain the phenomena of nature on known natural laws and forces, and with this view no phenomena are more interesting than those of the geographical distribution of species. The subject, in its full extent, would involve a solution of the much-vexed question of the origin of species; but whether species now living were derived from their relatives of a former geological age, or were independently created, we will not question in the present article, only taking species when they first appeared as they now exist, and contenting ourselves with some of the more prominent forces which bind them to peculiar habitats, or tend to diffuse them over wider or different areas.

These secondary causes, which act in the geographical distribution of species, are either inorganic or organic. Of the former the most important are the influences of topography, temperature, ocean currents, winds, and humidity; of the latter, animals themselves, and man,—for in this respect man must be separated from the mere brute animals as wielding a very different influence. The inorganic forces are so interwoven, they so act and react upon and limit each other, that

*"The Influence of Secondary Causes in the Geographical Distribution of Animals;" one of the subjects assigned for essays for the Berzelius prizes in the Sheffield Scientific School of Yale College in 1867.

they can scarcely be treated singly, and their influences are therefore discussed together; but the laws which govern the distribution of animals in the ocean are so different from those which govern the distribution of land and fresh-water species, that they are best treated separately.

The influence of topography in limiting the diffusion of marine species is too evident to require much explanation, and yet, uncombined with the influence of temperature, it would have little effect; for it is hardly possible to imagine a limit to the migration of species along coast lines and around capes from ocean to ocean, were the temperature of the water perfectly uniform. Still the mere separation of coasts by long intervals of deep water seems to have a direct influence in preventing the migration of certain groups of species; as, in the Pacific Ocean, under the same lines of temperature,* there are many species, especially of fishes and polyps, which are peculiar to each of the great groups of islands.

The influence of temperature has long been recognized as a most powerful cause in limiting the diffusion of marine species. Animals, with very few exceptions, are adapted for life and reproduction only within fixed limits of temperature, and a rise above or a fall below these limits, quickly puts an end to their existence. Such limits of temperature act as a continual check upon the effects of ocean currents in transporting species from place to place. Thus the Gulf Stream, flowing from the warm coral reefs of Florida and the Bahamas, must bear myriads of life-germs to the Bermudas and on across the Atlantic toward the Azores; but the isocrymal line of 68° F., which limits, on both sides of the equator, the reef-building corals† and most of the tropical

*The fact should not be overlooked that these isothermal and isocrymal lines indicate only surface temperature, and as there is yet very little known of deep ocean temperature, that it is quite possible that some species are retarded from descending to a sufficient depth to pass from place to place by the decrease in temperature; still the number of species must be small that can exist, even with the same temperature, at very different depths. (*Isothermal* is used to express equal annual temperature; *isocrymal*, equal temperature for the coldest month of the year.)

†Dana, United States Exploring Expedition, Vol. I, Zoöphytes.

marine species,* passes just north of the Bermudas, and all the germs of tropical life that cross this line must perish. The marine fauna of the West Indies extends to Bermuda, but, arrived at the Azores, the winter temperature has fallen to less than 60° F., and we have the fauna of the Mediterranean and none of the characteristic Bermuda species. On the other hand, in the Pacific, where the equatorial current flows continuously within the isocrymals of 68° north and 68° south, there are many species of mollusks, crustaceans, and echinoderms found from the Sandwich Islands to the coast of Africa, or through half the circumference of the globe.

The mere intervening deep ocean, without connecting islands, might prevent the occurrence of some of the Bermuda species at the Azores, as in the corals, the young of which probably cannot exist very long without becoming attached; but even along continuous coast lines, very few species extend through marked changes of temperature. On the western coast of America, a large part of the mollusks, crustaceans, echinoderms, and some polyps, extend from Lower California to Guayaquil and a few to Paita, Peru, but very few species are common to Guayaquil and to Callao, only a few hundred miles farther south. The isocrymals of 62° to 68° F. all converge near Cape Blanco, and such a change in temperature prevents the interchange of species between places north and places south of this point.†

The insular faunal character of the Americas has been remarked by many naturalists,—most of the marine species of

---

*Among the Crustacea, excluding the little known Entomostraca, Dana found, out of 1,036 species in the faunal torrid zone and 924 in the temperate zone, only seventy-five common to the two.—U. S. Expl. Exp., Vol. XIII, p. 1527. As the range of species becomes better known, the proportional number of species common to the two zones will undoubtedly be increased, but the fact is sufficient to show the great influence of temperature in limiting the diffusion of marine species.

†Many of the Peruvian, and some Panamic species, are found at Paita, and as usual there is a blending of the two faunæ at their junction; but this blending does not extend a great distance along the coast, and is what would be expected from the warm waters overlapping the colder. If there are species which have their centre of greatest development and abundance near the border of a fauna, it is nothing more than might be expected from the effects of temperature,—such species being adapted to a temperature intermediate between that of two faunæ.

both coasts belonging to peculiar American types,—and yet the shores of America are connected by zones of equal temperature with the Central and Western Pacific, and with the eastern shores of the Atlantic. How is this peculiar American character preserved? What prevents the interchange of species, if temperature is the great cause which limits their distribution? A glance at the ocean currents shows that none of them leave our shores without undergoing a marked change in temperature, and that none, from other shores, arrive upon them without undergoing a similar change. The Gulf Stream, after leaving the coast of the Southern States and the Bermudas, changes its temperature from 68° F. to 60° before its southern outflow reaches the Azores, and to almost 50° before it arrives on the shores of Europe. The Atlantic equatorial current is formed off the coast of Africa by the union of the returning Gulf Stream, flowing from Southern Europe and the Azores, and the northern current flowing from Cape Good Hope. These currents flow directly from temperate coasts into the torrid zone, which, by their influence, is narrowed down, on the western shores of Africa, to 20° of latitude, while on the American shores it extends through 60°. The antarctic current from Cape Horn flows northward into the warmer waters of the southern Atlantic. The antarctic polar current of the Pacific comes north from the frigid regions of the south into the temperate waters, is bent eastward against the shores of South America, and the principal branch flowing north along the coast is turned westward from Cape Blanco or Punta Parina, and, under the equator, still retaining the low temperature of the southern waters, sweeps into the torrid regions beyond the Galapagos. The current, flowing from the north along the western shores of the United States, leaves the coast of California and flows southward into the tropics. The frigid regions of North America are, of course, excepted, and the arctic American partake strongly of the character of the arctic species of the old world.

How beautifully these material forces act, binding each species to a special home, from which it may not wander and live. Nature places the bounds, the ocean waters may sweep by, but they cannot bear along the life which throngs them. These inorganic causes alone constitute the limits of faunæ, and can it be doubted that faunæ really exist in nature, when it is fully understood that all their modifications and complications are results of revolutions in these causes themselves? Let us look at some of these revolutions,—changes in topography, in temperature, and in ocean currents,—for thus far we have seen only how the diffusion of ocean species is limited by secondary causes.

We should begin when the first species of the present faunæ began to appear, and trace the changes to the present; but the data are very imperfect, and we can get only glimpses of these changes, yet enough to indicate some of the effects they have produced in the distribution of species. There is some uncertainty how far back in geological time species now living may have existed, but most authorities agree that at least a few of the present marine species were living in the Tertiary period, when Europe was scarcely more than an archipelago, when the lower Mississippi valley was a part of the Gulf of Mexico, and while Florida and the whole border of the southern Atlantic States were still swept by the waters of the ocean. But these few recent species were not then in their present homes; they have wandered, like the early races of men, southward.

The European fossil land faunæ and floræ indicate very clearly a change of climate from tropical to temperate during the Tertiary period, and in the marine climate there was a similar change. On the western shores of France, along the vallies of the Loire and the Ardour, there are deposits of early Tertiary mollusks and echinoderms, a large part of them extinct or unknown species, but a small part at least are still living in the Atlantic Ocean. These species are not, however, now found on the coast of France, but eight

or ten degrees farther south on the coast of Africa, and all the species of these ancient deposits partake of what is now a more southern character.*

During the Tertiary period there was a gradual but very extensive elevation of the northern part of the continents. It was during this period that the Alps and the Pyrenees were raised to their present level. The lifting at the north of such masses of land into the cooler regions of the atmosphere would have had a powerful influence in reducing the temperature of the neighboring seas. As the waters became slowly cooled, the species best adapted to migrate gradually extended their limits southward; on the north, the species were destroyed by the advancing cold, and all those species with little power of migrating, and those easily affected by changes of temperature or other physical causes were wholly exterminated. And thus, on the shores of Africa, still exist the remnants of the ancient Tertiary fauna of the southern European seas, driven from their former home by the advancing cold, but living on through all the changes, even of a Glacial epoch.

In North America, the land climate during the early and middle Tertiary was warmer than now, as is indicated by the plants of the lignite beds, and the marine climate undoubtedly corresponded with that of Europe and with that of the land. In the northern parts of the country no fossil records of the later marine Tertiary are known, but the land faunæ of the period, the upheaval of the northern parts of both countries, and the changes in the European seas show very clearly that there were similar changes on the American shores.

The arctic marine fauna of the earlier Tertiary, while much more land than now was submerged at the north, must have been circumpolar in character, and the retreating of species southward from this common point accounts for the occurrence of the same species on the northern coasts of both

*Forbes, Natural History of the European Seas.

continents. Even those few species which are common to the temperate regions of both oceans or the shores of both continents, and not now found in the intermediate northern regions, may have been driven in the same manner southward, until the intervening continent or ocean left the remnants of the old circumpolar fauna widely separated in more southern regions. Why call to the aid of modern theories the mythical Atlantis to bear species across the ocean, when known climatic changes can have led them gradually from a common home at the north?

The marine fossils of the latest Tertiary of Europe, and doubtless of North America also, are very largely living species;* and at that time, the climate of the North Atlantic was nearly like that of the present. In the absence of any knowledge of fossil deposits contemporaneous with the earlier Glacial period, it is impossible to arrive at any definite conclusions in regard to the geographical distribution of the species at that time.† Still, the number of species which continued to live on through the Glacial epoch, the absence of well marked and extensive glacial phenomena from middle latitudes, and the appearance, in the decline of the Glacial period, of species near their present habitats, are good negative evidence that there was no very extensive southern migration of marine life during that period.

Darwin, in the "Origin of Species," supposes the cold of the Glacial period sufficient to have driven the species from the arctic and from the antarctic to the equator, and thus accounts for the similarity of the living species of those regions. Such intense cold would have been sufficient to destroy all life in the North Atlantic; and it can scarcely be supposed that species would travel from far north to the

* Lyell gives the proportion of living species of shells found in the Norwich Crag, in England, as ninety per cent. or more.—Principles of Geology, Amer. Edit., p. 143.

† A careful investigation of the later Tertiary of the Southern States, and its comparison with the Post-tertiary, would throw much light upon the extent of the disturbances in the geographical distribution of species in the North Atlantic during the true Glacial epoch.

equator and back again without leaving some traces behind them. Nor are the faunæ of the arctic and of the antarctic so closely allied as has sometimes been supposed. There is no well-authenticated instance of the same animal species occurring in each of the frigid latitudes, except such as have an intermediate or cosmopolitan existence.*

As Dr. Packard† has shown, the submerged beaches give very good evidence that the boreal and arctic regions of North America during the true Glacial epoch, stood at a much higher level above the sea than at present. This elevation was undoubtedly enough to raise the submerged border of the continent, the Gulf of St. Lawrence, the Banks of Newfoundland, and the banks off the coast of Nova Scotia, Maine, and Cape Cod, above the sea-level. As the rise and enlargement of the lands at the north during the Tertiary period had changed the climate of Europe and the northern parts of North America from tropical to temperate, this elevation during the Glacial epoch must have changed the climate of these regions from temperate to frigid, and brought the snow line down to the coast of New England. Such an enlargement of lands at the north would not, however, change materially the climate of the tropics, and it is altogether probable that the Gulf Stream flowed on and warmed the southern coast as it did in the Tertiary and does now, and that the coral reefs of Florida and the West Indies were then slowly building beneath its warm waters.

* Professor Lilljeborg, in a recent paper (noticed in the NATURALIST, p. 48), in the Trans. Scientific Soc. at Upsala, on the *Lysianassa Magellanica* Milne Edwards, and on some other Crustacea of the suborder Amphipoda, on the coast of Sweden and Norway, while admitting that no species had previously been found common to both frigid zones and not in intermediate localities, claims to have discovered, in a gigantic Amphipod living upon the coast of Norwegian Finmark, the *Lysianassa Magellanica* of Milne Edwards. Bate has shown, however, in the Zoölogical Record for 1865, p. 330, that the arctic species is not only specifically distinct from the *Lysianassa* of Milne Edwards, but that it cannot be referred to that genus. Such facts show how very difficult it is to prove the identity of animals from far separated localities, without a direct and careful comparison of specimens, and how little confidence can be placed in the reported identity of such animals.

† Observations on the Glacial Phenomena of Labrador and Maine. Memoirs Boston Soc. Nat. Hist., Vol. I, Part II. Many of the facts, on several succeeding pages, are drawn almost wholly from this very interesting paper.

The sinking of the lands which closed the true Glacial epoch, carried the coast line higher than it is now, as is shown by the fossil deposits of the Leda Clays (Champlain epoch), found along the coast and far up the lower vallies from Labrador to New York. It might at first be supposed that such a depression would induce a climate even warmer than the present; but a depression of six or seven hundred feet would have made islands of New England and Nova Scotia, and opened a way for the Labrador current from the Gulf of St. Lawrence into the Bay of Fundy and along the coast of Maine, and, at the same time, would have allowed a branch of the current to flow up the valley of the St. Lawrence River into Lake Champlain, and very likely down the valley of the Hudson. Such a surrounding flood of arctic waters would have reduced the summer temperature of the land, and carried the arctic marine species somewhat south of their present limits.

The species left fossil in the Leda beds confirm this, and show very accurately the distribution of marine life at the time these beds were formed. The species of the earlier Labrador beds are more purely arctic than the present fauna of that coast.* The beds of fossils at Portland and Saco indicate that the Syrtensian fauna extended into the mouth of the ancient Casco Bay, as it now does into the mouth of the Bay of Fundy. At Point Shirley, in Massachusetts Bay, the species of the Leda beds belong almost exclusively to the Virginian fauna, which is now found only south of Cape Cod.† This shows that a branch of the Gulf Stream flowed over the eastern end of Long Island, and across submerged Cape Cod, into Massachusetts Bay. Thus, since all, or nearly all the marine species which now inhabit our coast were in existence, arctic species extended into southern Maine, and species, now living only south of Cape Cod, extended north to Cape Ann. The southern outliers of the Syrtensian

*Packard, loc. cit., p. 234.

†Stimpson, Proceedings Bost. Soc. Nat. Hist., Vol. IV, p. 9, 1851.

and Acadian faunæ, on the deep water-banks off the New England coast, are thus shown to be relics of the northward migration of these faunæ. — *To be concluded.*

THE HAIRY MAMMOTH.

BY A. S. PACKARD, JR., M. D.

In 1799, Schumachoff, a Tungusian hunter, discovered at the mouth of the river Lena a shapeless mass frozen in the ice. But not until two years after, 1801, when the ice had so melted that the tusks and one side of the animal were disclosed, did he know upon what a monster he had stumbled. Returning to his home on the borders of Lake Oncoul, he told his family of the strange creature entombed in the ice. They were seized with consternation, for in the days of yore some hunter had found on this peninsula the same sort of animal, and his family had all died soon afterwards.

Death, however, did not invade the household. The god of mammon reigned instead. On recovering from the nearly fatal sickness into which his superstitious fears had thrown him, our enterprising ivory-hunter, led on by the greed of gain, revisited the Mammoth Golgotha, and in March, 1804, favored by the warm weather, beheld the gigantic carcass, now become historic, reposing free from its icy tomb on the sands of the Lena. He sold the tusks for fifty roubles, and the carcass was left to the tender mercies of the people about, who fed their dogs on the flesh, while "wild beasts, such as white bears, wolves, wolverenes, and foxes also fed upon it, and the traces of their footsteps were seen around." The skeleton remained entire, except one foreleg, which some unusually enterprising white bear probably lugged off. Professor R. Owen, whose account we have been using, states that, —